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## S1 New Curriculum Physics

### Theme: Heat

### Chapter 5 –Temperature measurements



## Heat

Heat (**also called** thermal energy) is a form of energy which that rises the temperature of substances. **Heat energy** is due to the movement of particles within a substance. The faster these particles move, the more heat energy the object has.

### Effect of heat on substances

Heat affects substances in several ways, causing physical and chemical changes.

- (i) **Temperature Increase:** As heat is added, the temperature rises, which can increase the speed of chemical reactions.
- (ii) **Expansion and Contraction:** When heated, most substances expand because their molecules move faster and spread apart. When cooled, they contract as the molecules slow down and come closer together. This is why bridges and rail tracks have gaps—they need space for expansion in hot weather.
- (iii) **Changes in State (Phase Changes):** Heat can change a substance's state, i.e.

- **Melting** – Solid to liquid (e.g. ice to water).
- **Boiling/Evaporation** – Liquid to gas (e.g. water to steam).
- **Condensation** – Gas to liquid (steam to water).
- **Freezing** – Liquid to solid (water to ice).

Melting and freezing occur at the same specific temperature called **melting point** while boiling and condensation also occur at the same specific temperature called **boiling point**.

- (iv) **Chemical Reactions:** Heat can cause substances to undergo irreversible changes, like burning paper or cooking food. Some reactions need heat to start, like combustion or thermochemical processes.
- (v) **Electrical Property Changes:** Heat affects electrical conductivity—some materials become better or worse conductors at different temperatures.
- (vi) **Magnetic Property Changes:** Magnets may lose their magnetic properties when heated beyond a certain point.

## Temperature

Temperature is the degree hotness or coldness.

The extent to which the body feels hot depends on the; average kinetic energy of the individual atoms or molecules with in that body. This means that the body's kinetic energy is directly proportional to its thermal dynamic temperature.

### Units of Measurement of temperature

- **Celsius (°C)** – Used in most of the world.

$$C = \frac{5}{9}(F - 32)$$

- **Fahrenheit (°F)** – Common in the United States.

$$F = \frac{9}{5}\theta + 32$$

- **Kelvin (K)** – Used in scientific calculations.

$$K = 273 + ^\circ C$$

### Temperature vs. Heat

While heat is a form of energy transfer due to temperature differences, temperature itself is just a measure of thermal energy.

### Thermometers

It is an instrument that measures temperature

## Thermometric properties

A **thermometric property** is a physical quantity which varies continuously, uniformly and linearly with temperature and remains constant at constant temperature.

## Types of thermometers

Different types of thermometers use different thermometric properties to measure temperature accurately.

Type of Thermometer	Thermometric Property Used	Common Uses
<b>Mercury Thermometer</b>	Expansion of mercury with temperature	Medical, laboratory, industrial applications
<b>Alcohol Thermometer</b>	Expansion of alcohol with temperature	Cold environments, meteorology
<b>Constant Volume Gas Thermometer</b>	Pressure change of a fixed mass of gas	Scientific research, calibration of other thermometers
<b>Thermocouple Thermometer</b>	Changes in electromotive force (e.m.f.)	Industrial temperature measurement, scientific experiments
<b>Resistance Thermometer (Thermistor)</b>	Changes in electrical resistance	Precision temperature measurement in electronics and industry
<b>Bimetallic Strip Thermometer</b>	Expansion of different metals at different rates	Ovens, thermostats, industrial equipment
<b>Infrared Thermometer</b>	Detection of infrared radiation emitted by objects	Medical, food safety, industrial applications
<b>Pyrometer</b>	Measurement of thermal radiation intensity	High-temperature environments like furnaces and kilns

## Calibration of a thermometer

To **calibrate a thermometer** means to adjust and verify its accuracy by comparing its readings to a known reference temperature. This ensures that the thermometer provides correct measurements, which is crucial in fields like medicine, food safety, and scientific research.

## Definitions

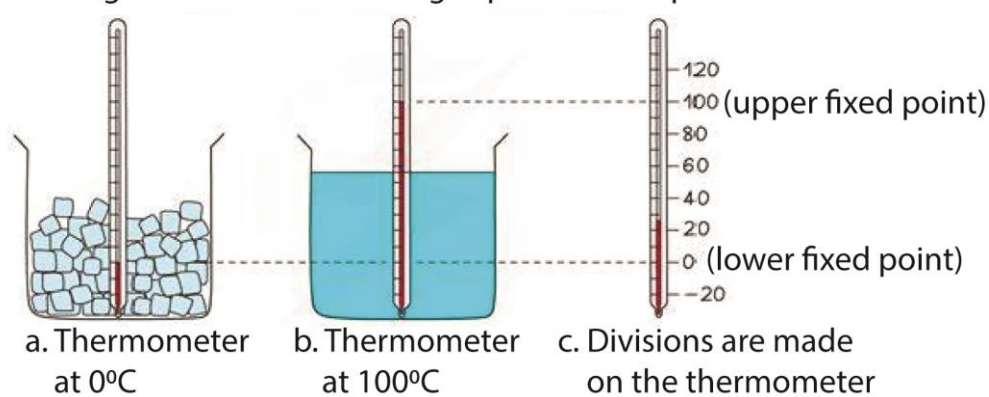
- (i) **Fixed point** is defined as constant temperature at which a physical state of pure water is expected to change at 760mmHg. Fixed points are basically two i.e.  $0^{\circ}\text{C}$  and  $100^{\circ}\text{C}$ .
- (ii) **Lower fixed point ( $T_0$ )** is the temperature of pure melting ice at 760 mmHg. It is  $0^{\circ}\text{C}$ .
- (iii) **Upper fixed point ( $T_{100}$ )** is the temperature of pure steam at 760mmHg. It is  $100^{\circ}\text{C}$ .

## Establishing Celsius scales of temperature

- (i) Chose a physical property of substance (X)
- (ii) Determine the value of the property at the upper fixed point of the thermometer ( $X_{100}$ ). This is done by placing the bulb of the thermometer in steam at 760mmHG until a constant reading is obtained.
- (iii) Determine the value of the property at the lower fixed point of the thermometer ( $X_0$ ). This is done by placing the bulb of the thermometer in melting ice at 760mmHG until a constant reading is obtained.
- (iv) If the value of the thermometric property at temperature,  $\theta$ , is  $X_\theta$ .

$$\text{Then } \theta = \left( \frac{X_\theta - X_0}{X_{100} - X_0} \right) \times 100^\circ\text{C}$$

### Finding the Celsius Scale using expansion of liquids



- a. Place the thermometer in melting ice mark the reading of the thermometer as  $0^\circ\text{C}$ .
- b. Place the thermometer in boiling water and mark the reading of the thermometer as  $100^\circ\text{C}$ .
- c. Find the **fundamental interval** or length between  $0^\circ\text{C}$  and  $100^\circ\text{C}$ ; and divide into 100 divisions each representing  $1^\circ\text{C}$ .

### Importance of calibrating a thermometer

- Ensures **accuracy** in temperature measurements.
- Prevents **errors** in scientific experiments and food safety.
- Meets **regulatory standards** in industries like healthcare and manufacturing.

### Example

When measuring the temperature of water, Tony obtained the following results.

Length of mercury in ice = 3cm

Length of mercury in steam 20cm

Length of mercury in water = 9cm

Determine the temperature of water

Solution

$$\text{Temperature of water} = \frac{9-3}{20-3} \times 100 = 35^{\circ}\text{C}$$

**Examples of thermometric liquids are mercury and alcohol.**

**Advantages of mercury in thermometers**

- withstands high temperature without change of state
- does not wet glass
- expands uniformly

**Disadvantage of mercury in thermometers**

- it is expensive
- it is poisonous

**Advantages of alcohol in thermometer**

- Advantage
- Measures low temperatures because of its low freezing point
- Cheap
- Can measure very low temperatures

**Disadvantages of alcohol in thermometer**

- does not measure high temperature above  $78^{\circ}\text{C}$ .
- wets glass
- Water is not used because it has irregular expansion
- Cannot measure temperatures below  $0^{\circ}\text{C}$  or above  $100^{\circ}\text{C}$

**Atmospheric temperature**

It the temperature on the earth's atmosphere

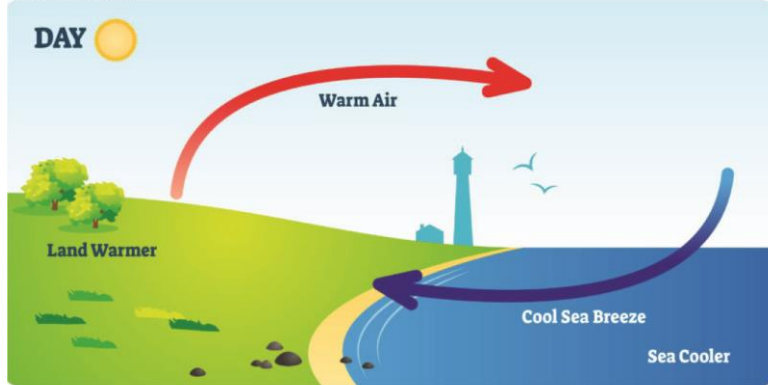
**Factors that affect atmospheric temperature**

Several factors influence **atmospheric temperature**, shaping climate and weather patterns.

1. **Latitude** – Areas near the equator receive more direct sunlight, leading to higher temperatures, while polar regions get less solar energy, making them colder.
2. **Altitude** – Temperature decreases with height because the atmosphere is heated from the Earth's surface. Higher elevations experience cooler temperatures.
3. **Ocean Currents** – Warm ocean currents raise temperatures in coastal areas, while cold currents lower them by transporting heat across regions.
4. **Cloud Cover** – Clouds can trap heat, keeping nights warmer, or reflect sunlight, making days cooler.

5. **Humidity** – Moist air retains heat better than dry air, affecting temperature variations.
6. **Earth's Rotation & Tilt** – Seasonal changes occur due to Earth's axial tilt, influencing temperature distribution.
7. **Greenhouse Gases** – Gases like carbon dioxide and methane trap heat, increasing global temperatures.

#### Sea breeze



During day, the land is heated to a high temperature than the sea. Hot air expands and rises from land. A stream of cool air from the sea blows towards the land to replace the uprising air, hence sea breeze occurs.

#### Land breeze



At night the land cools faster because it is no longer heated by the sun. The sea retains the warmth because it is heated deeply. Warm less dense air rises from the sea surface and air from land blows to replace it leading to land breeze.

#### Revision questions

1. Explain and identify the fixed points of s Celsius scale of temperature.
2. What are the advantages and disadvantages of alcohol and mercury as liquids in thermometers
3. With examples, explain the meaning of the term thermometric property

4. Express  $25^{\circ}\text{C}$  on Fahrenheit scale
5. When a Celsius thermometer was inserted in boiling water, melting ice and liquid X, the lengths of the thread was 18cm, 3cm and 11cm respectively. Find the temperature of liquid X

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